

(12) UK Patent Application (19) GB (11) 2 361 947 (13) A

(43) Date of A Publication 07.11.2001

(21) Application No 0109632.0

(22) Date of Filing 19.04.2001

(30) Priority Data

(31) 60198605 (32) 19.04.2000 (33) US

(71) Applicant(s)

Baker Hughes Incorporated
(Incorporated in USA - Delaware)
3900 Essex Lane, Suite 1200, P.O. Box 4740, Houston,
Texas 77210-4740, United States of America

(72) Inventor(s)

Darrin L Willauer
Richard Van Buskirk

(74) Agent and/or Address for Service

Murgitroyd & Company
373 Scotland Street, GLASGOW, G5 8QA,
United Kingdom

(51) INT CL⁷

E21B 33/127

(52) UK CL (Edition S)

E1F FKA

(56) Documents Cited

GB 2349657 A US 5868201 A US 5417122 A

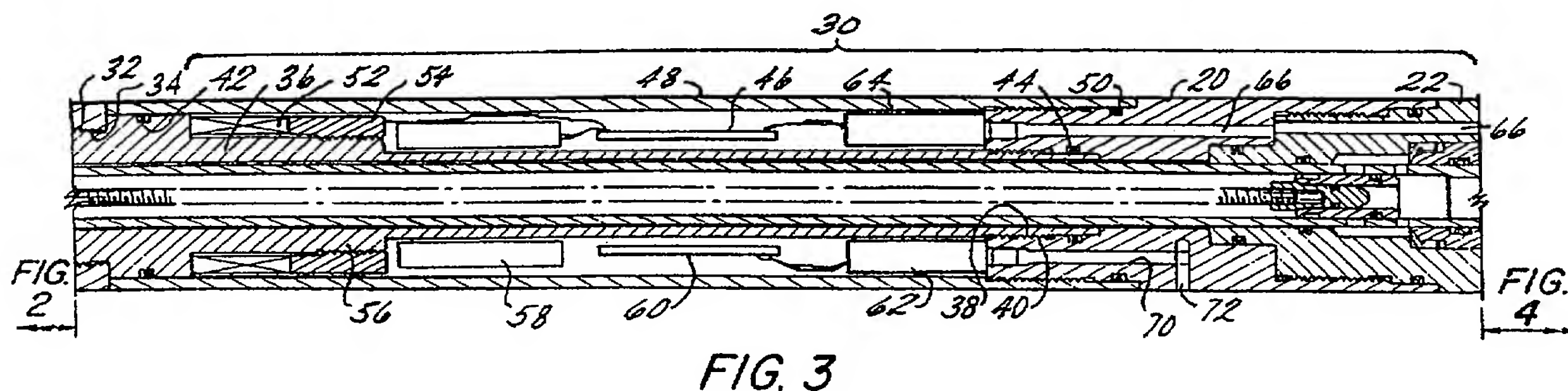
(58) Field of Search

UK CL (Edition S) **E1F FKA FKF**
INT CL⁷ **E21B 33/10 33/12 33/127 33/134**

(54) Abstract Title

Intelligent through tubing bridge plug with downhole instrumentation

(57) A through tubing retrievable bridge plug comprises an inflatable element, a sensor module 30, a control module 60 and a transmitter 52. The sensor module 30 comprises at least one sensor to monitor downhole parameters such as temperature, flow rate, gamma radiation, radio waves, electromagnetic waves, or pressure either within the inflatable element or in the annulus formed above and below the inflatable element. The transmitter 52 transmits acoustically, by radio or electro-magnetic waves or by vibration.



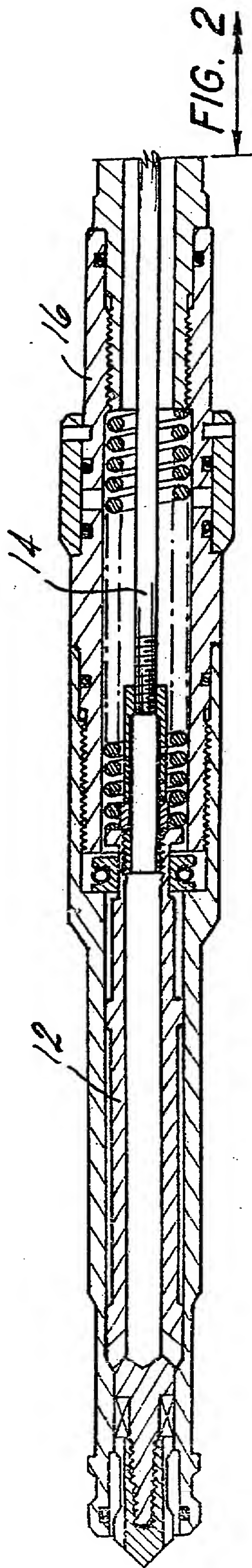


FIG. 1

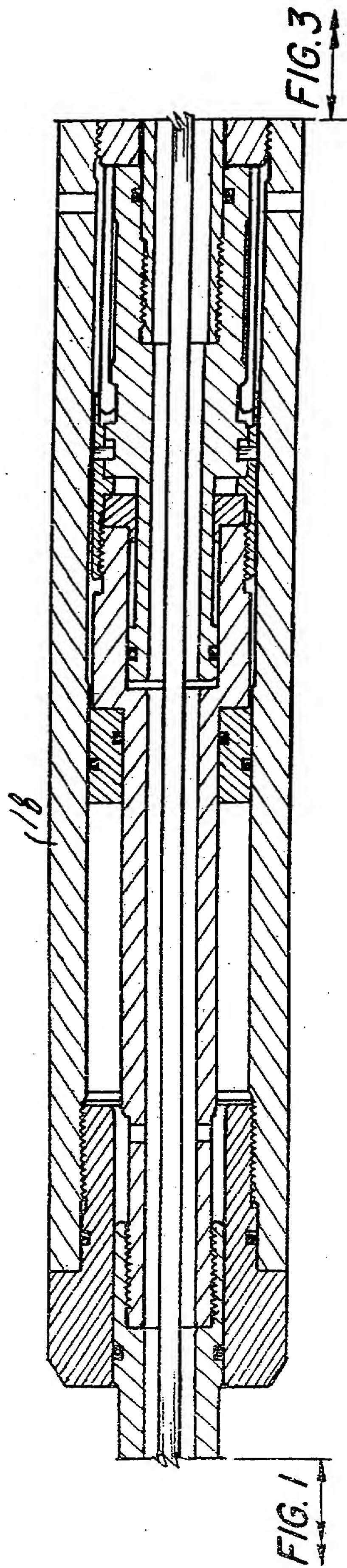


FIG. 2

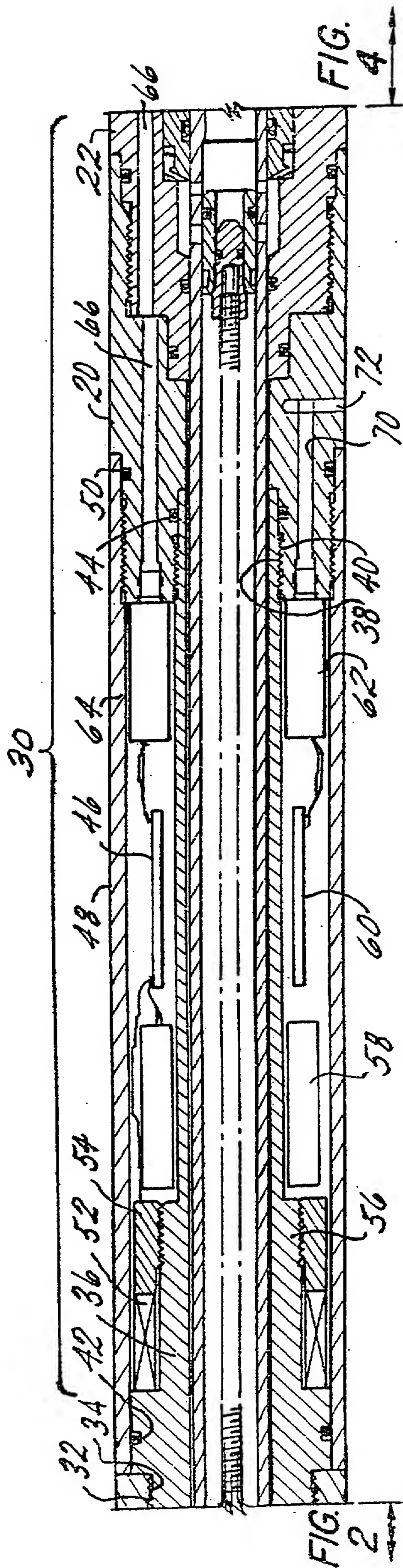


FIG. 3

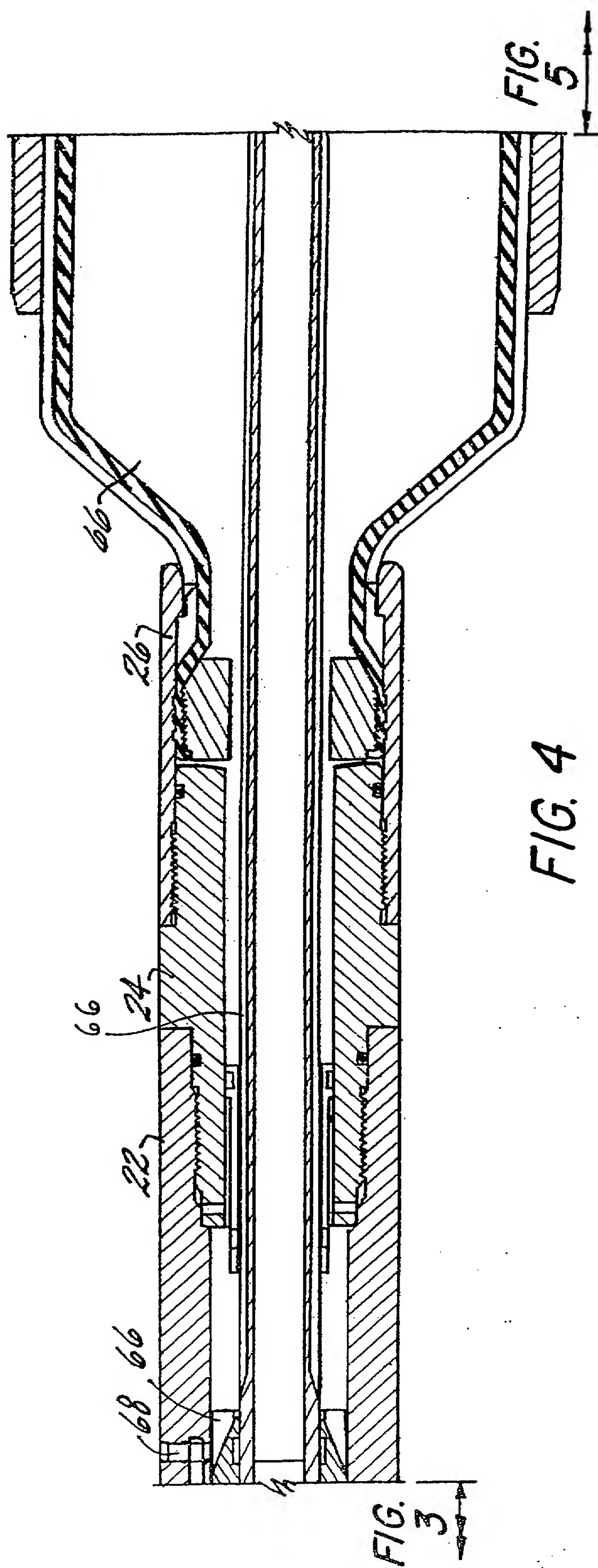


FIG. 4

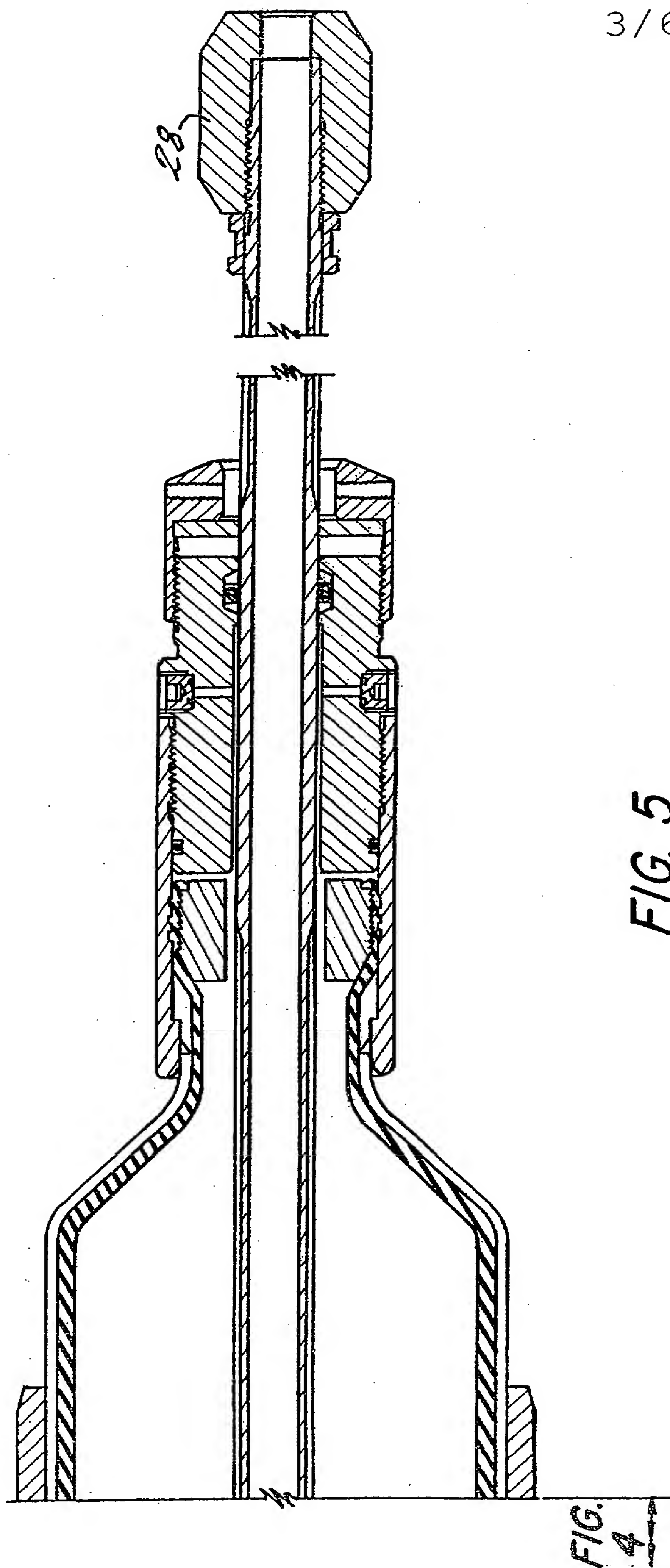
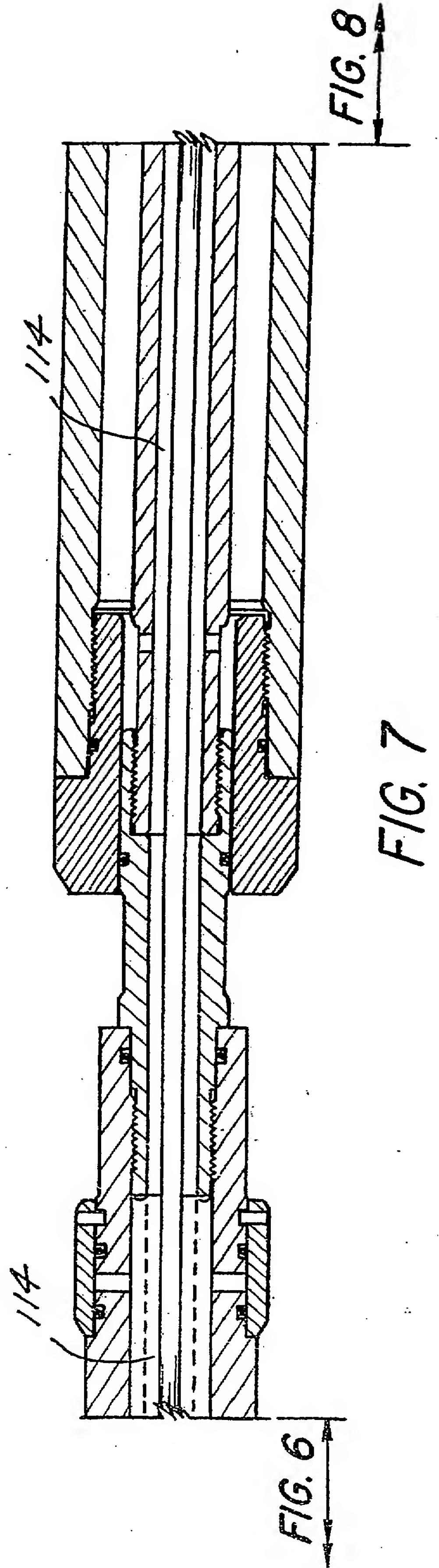
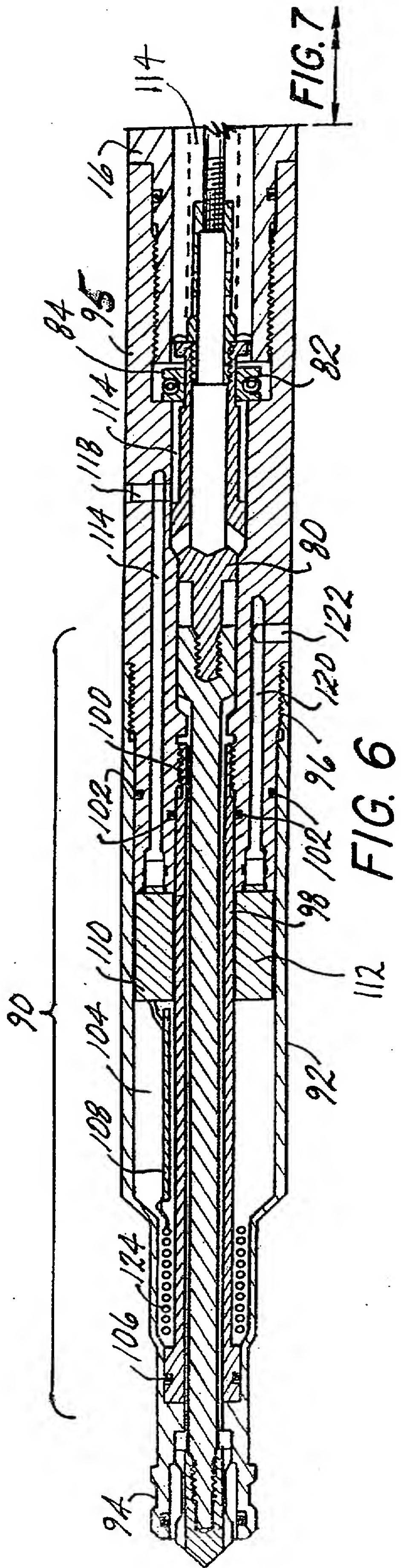
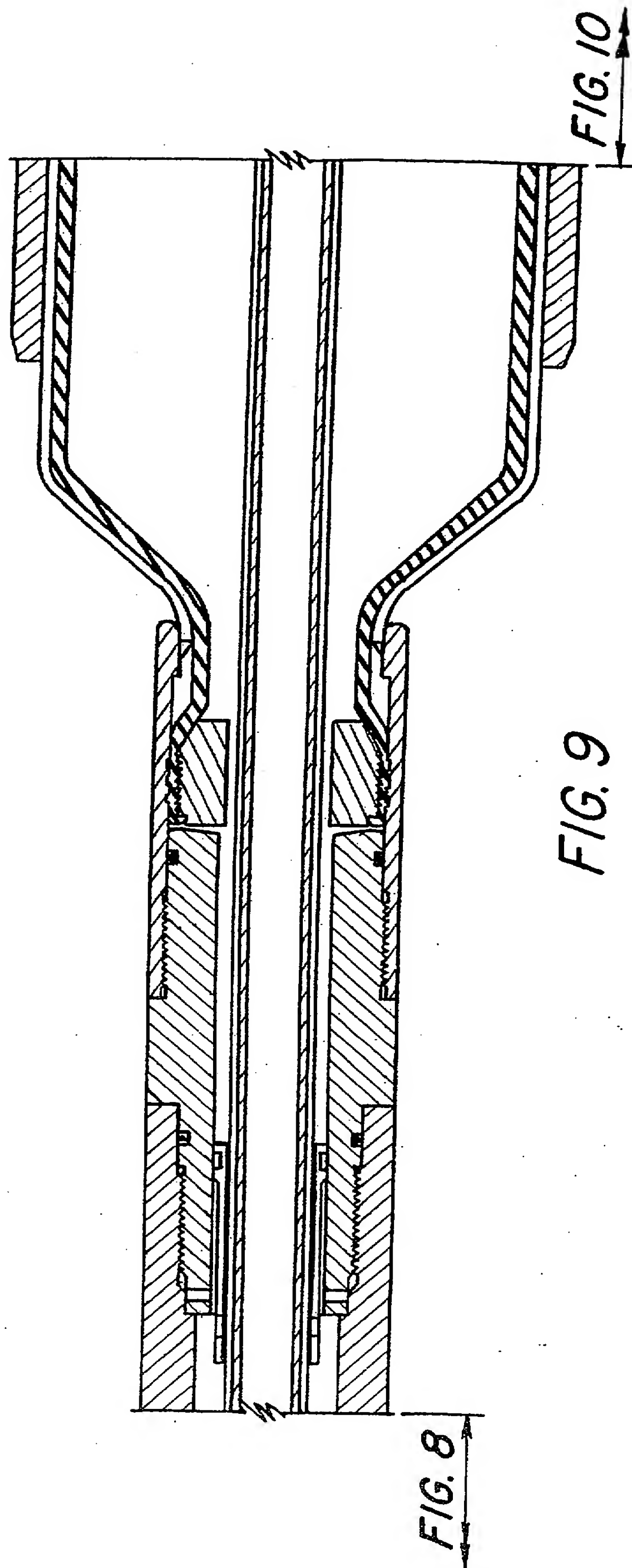
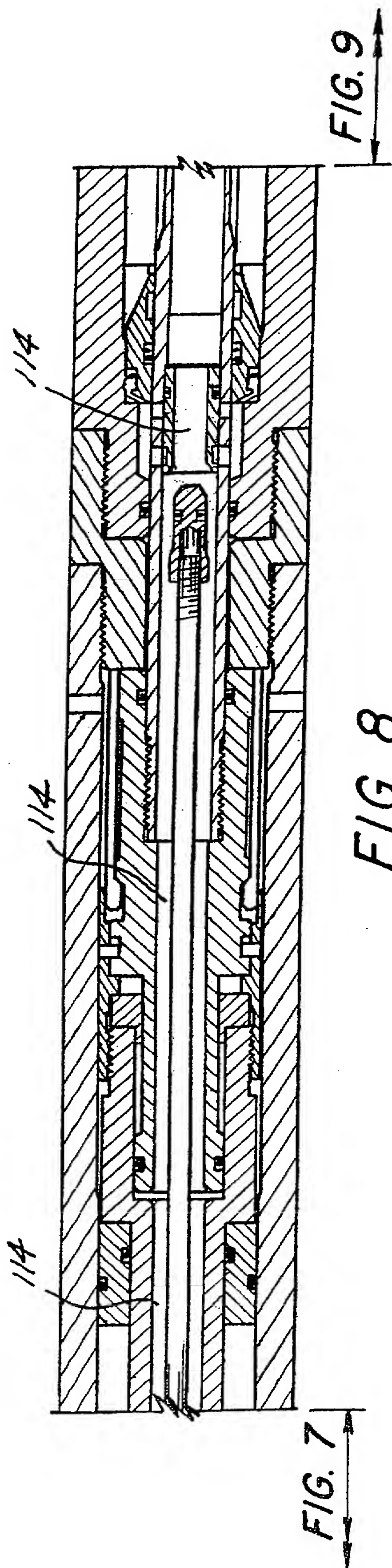


FIG. 5

FIG. 4





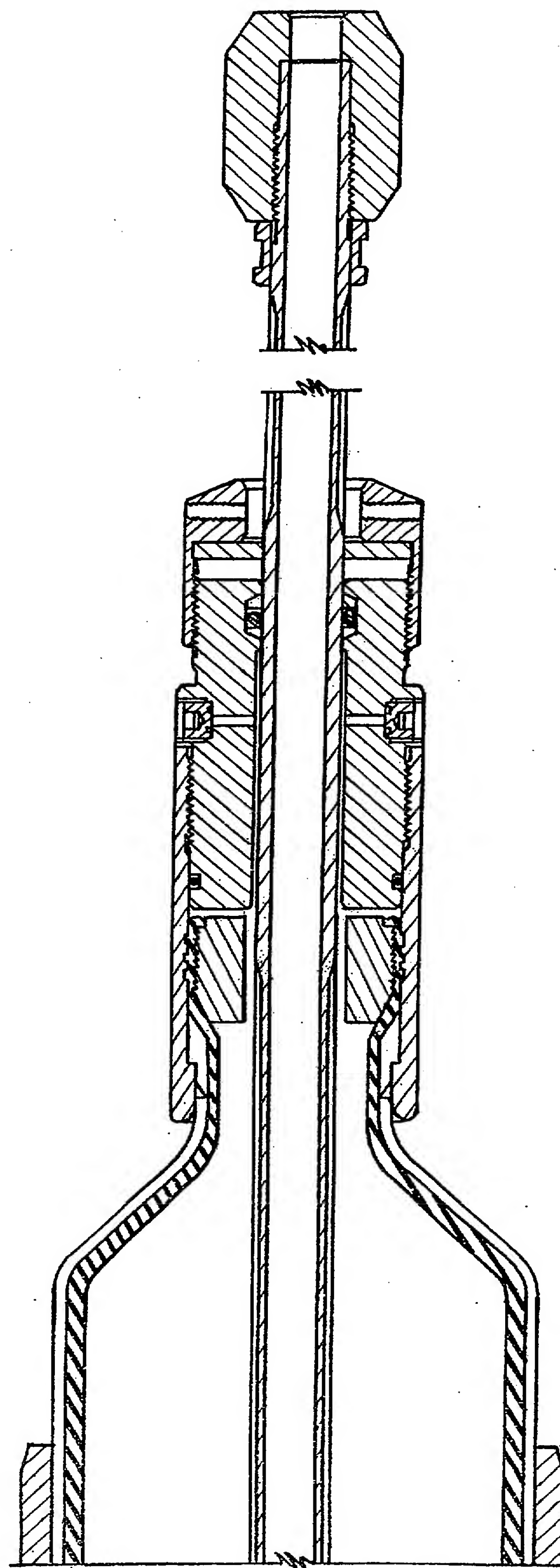


FIG. 10

FIG. 9

1 INTELLIGENT THROUGH TUBING BRIDGE PLUG WITH DOWNHOLE
2 INSTRUMENTATION

3

4 BACKGROUND

5 Thru tubing retrievable bridge plugs provide a
6 means of temporarily plugging selected sections of a
7 well, without the need for pulling production
8 tubing. Avoidance of the need to pull the
9 production tubing dramatically reduces costs
10 associated with plugging particular sections of a
11 well. Different sections of a well might need to be
12 plugged because of, for example, water breakthrough,
13 gas production, etc. Retrievable bridge plugs are
14 also run to plug certain sections of a well in order
15 to test different fluids flowing into the well at
16 that location or above that location from shallower
17 zones within the wellbore. Such bridge plugs
18 generally include a lower valve which provides a
19 seal, blanking off a section of mandrel so that a
20 packer element, also contained within the
21 retrievable bridge plug, can be inflated. The
22 packing element provides for the plugging off of the
23 selected sections of the well. The construction and
24 use of a conventional bridge plug is considered
25 known to one of ordinary skill in the art. Such
26 bridge plugs are commercially available from many
27 sources including Baker Oil Tools, Houston, Texas
28 (Product Nos. 340-10 and 330-72).

29

30

31

32

1 SUMMARY

2 The above-identified drawbacks of the prior art
3 are overcome, or alleviated, by the intelligent
4 bridge plug system of the invention.

5 The present invention avails itself of the
6 benefits evident in conventional retrievable bridge
7 plugs and further provides a method and apparatus
8 for accurately setting the inflation pressure of a
9 retrievable bridge plug and verification of that
10 setting. The apparatus of the invention is a thru
11 tubing bridge plug having downhole instrumentation
12 and employing an electric wireline setting tool such
13 as that disclosed in co-pending U.S. Serial No.
14 60/123,306, filed March 5, 1999, the entire contents
15 of which is incorporated herein by reference. The
16 device further comprises several sections of a
17 retrievable bridge plug and several downhole
18 sensors. The sensors are worked into the tool
19 preferably in a sensor module which is a part of the
20 retrievable bridge plug assembly. The sensor module
21 is located in different sections of the tool for
22 different embodiments as disclosed hereinbelow. The
23 tool of the invention preferably measures element
24 inflation pressure, temperature inside the packer
25 and the annulus temperature as well as pressure
26 uphole of (above) and downhole of (below) the
27 packer. These parameters of the well may be used to
28 ensure a proper setting of the inflatable element
29 and thereby ensure that the bridge plug operates as
30 intended. The invention provides a superior
31 advantage over the prior art for many reasons
32 including that the temperature of the inflation

1 fluid is nearly always cooler than the temperature
2 downhole. If a packer is fully inflated with
3 relatively cooler fluid, the thermal expansion of
4 that fluid subsequent to filling could rupture the
5 element. Such occurrence could be problematic and
6 would preferably be avoided. The present invention
7 provides the means to avoid such a condition and
8 also will provide a high degree of confidence that
9 the inflatable element is properly inflated every
10 time the bridge plug is employed.

11 It is also important to note that one of the
12 key points in measuring pressure below the bridge
13 plug is to determine how the well is responding to
14 the plug. This is an important benefit of the
15 invention not heretofore available; comparing
16 pressure above the plug with pressure below the plug
17 which provides information about whether or not a
18 zone has been effectively shut off and whether or
19 not the packer has achieved a good seal. The
20 existence of leaking through the casing or through
21 fractures in the formation, etc. would be identified
22 by comparing the above and below pressure.
23 Moreover, the comparison indicated above provides
24 information about whether or not pressure below a
25 plug is being adversely affected by other wells in a
26 situation where production wells and injection wells
27 are operating in the same field. Furthermore, by
28 monitoring all three of above the plug pressure,
29 below the plug pressure and element inflation
30 pressure verification can be obtained that the
31 inflation pressure ratings for the element being
32 employed have not been exceeded.

1
2 IN THE DRAWINGS

3 FIGURES 1-5 are an elongated view of a cross-
4 section with a first embodiment of the invention;
5 and

6 FIGURES 6-10 are an elongated view of a cross-
7 section of a second embodiment of the invention.
8

9 DETAILED DESCRIPTION

10 Referring to Figures 1-5, a first embodiment of
11 the invention is illustrated. It will be
12 appreciated by one of ordinary skill in the art that
13 Figures 1 and 2 and Figures 4 and 5 depict portions
14 of the inventive bridge plug that are identical to a
15 prior art bridge plug commercially available from
16 Baker Oil Tools, Houston, Texas, under Product
17 Nos.340-10 and 330-72. Since these portions are
18 very well known to the art, a detailed description
19 thereof is not necessary to a full understanding of
20 the invention. For orientation and clarity, one of
21 skill in the art will recognize upper valve sleeve
22 12, valve shaft 14 and equalizing mandrel 16 in
23 Figure 1. In Figure 2, bumper housing 18 and
24 associated components will be recognized.

25 Referring now to Figure 3, the sensor module 30
26 of the invention is illustrated. Sensor module 30
27 is important to the function desired in the present
28 invention since it houses all of power, telemetry
29 and sensor assemblies. Module 30 is essentially
30 "cut into" the conventional tool in the position, in
31 this embodiment, illustrated by Figures 1-5. Where
32 bumper housing 18 would be connected to collet sub

1 20 in a prior art tool, the sensor module 30 is
2 connected therebetween. It is important to note
3 that collet sub 20 is modified in the invention to
4 provide pressure paths which allow the sensing
5 desired in the invention to take place. Poppet
6 housing 22 is also modified, again to provide a
7 pressure path for the sensing desired in the
8 invention. Pressure is measured at the back side of
9 the poppet to obtain accurate element pressure. The
10 balance of the tool in this embodiment, referring to
11 Figures 4 and 5 is conventional. One of skill in
12 the art will recognize spring housing 24 connected
13 to poppet housing 22 and element 26 connected to
14 spring housing 24. Guide 28 is shown at the
15 downhole end of the tool at the right side of Figure
16 5.

17 Referring back to Figure 3, the detail of the
18 invention is discussed. At the box thread 32 of
19 bumper housing 18, an uphole end of sensor module 30
20 is provided with a pin thread 34. The pin thread 34
21 is actually cut on a mandrel 36 of sensor module 30.
22 Mandrel 36 is connected at its downhole end at pin
23 thread 38 to collet sub 20 via box thread 40.
24 Mandrel 36 is made pressure tight between tubing
25 pressure and exterior wellbore pressure by o-rings
26 42 and 44 on the uphole and downhole ends thereof,
27 respectively. Since sensitive electronic equipment
28 must be delivered to the downhole environment in
29 this tool, it is necessary to create a sealed
30 chamber which may be atmospheric or hydraulic fluid
31 filled. The chamber is numeraled 46 and is formed
32 annularly between mandrel 36 and sleeve housing 48.

1 Sleeve housing 48 shares an o-ring with mandrel 36
2 at 42 and is provided with an additional o-ring 50
3 at an outer surface of collect sub 20. Chamber 46
4 is filled, in the invention, with a transmitter 52
5 locked in a desired position as shown by locking
6 ring 54 which is threadedly connected to mandrel 36
7 at thread 56. Transmitter 52, preferably a piezo
8 ceramic transducer, is connected via contacts (not
9 shown) to an electrical control module with signal
10 receiver 60 which is connected to battery pack 58.
11 The control module regulates power to the
12 transmitter 52, receiver 60 and the pressure
13 transducers. Typically, a sine or square wave is
14 sent to the transmitter to create either pulser or
15 frequency acoustic outputs. It should be noted that
16 several different control modules 60 or a single
17 annular one may be employed. It is preferable to
18 employ several modules 60 to reduce cost of
19 manufacture. Constructing annular circuit boards
20 for modules is expensive. The one or more modules
21 60 are connected to pressure transducers 62 and 64
22 which each monitor pressure in a different place via
23 pressure pathways as shown. Pressure transducer 64
24 is "plumbed" to element pressure via pathway 66.
25 Numeral 66 is repeated several times in the drawings
26 to indicate the pathway. It will be noted that plug
27 68 is provided to close annular pressure from
28 conduit 66. The plug is needed as a consequence of
29 the manufacturing process for creating the pressure
30 pathway 66 to element pressure.

31 In the case of pressure transducer 62, a
32 pressure pathway 70 is provided which is left open

1 to annulus pressure at port 72. This transducer
2 will sense annulus pressure above the element 26
3 (Figure 5). Differences between this pressure
4 location and pressure below the element provides
5 information about the setting of the element 26.
6 Pressure below the annulus is measured by a similar
7 set of components which cannot be seen in this
8 drawing but will be understood to one of skill in
9 the art by exposure to the shown component sets
10 illustrated.

11 The tool as described is operable in several
12 modes. One mode is a continuous data stream mode
13 wherein the transmitter of the invention transmits
14 acoustic (radio wave, electromagnetic wave,
15 vibration or other) data at all times. As required
16 or desired, a receiver is run in the hole to acquire
17 the acoustic (radio wave, electromagnetic wave,
18 vibration or other) signal and transmit data uphole.
19 It should be noted that in situations where it is
20 physically possible for the signal from the
21 transmitter to reach the surface on its own, a
22 receiver can be positioned at the surface. In
23 another mode of operation of the invention, data is
24 stored downhole until a signal to transmit is
25 received by the tool. The signal could be generated
26 at the surface and sent downhole or generated
27 downhole by a receiver run in the hole for that
28 purpose and for retrieving the data released.

29 In another embodiment of the invention,
30 referring to Figures 6-10, a sensor module is
31 differently configured and is located in a position
32 within the otherwise conventional (except for

1 pressure pathways) bridge plug. Power and
2 communication is provided through an inductive
3 coupler coil discussed hereunder. In this
4 embodiment, it is the uphole end of the tool which
5 is most modified from its conventional cousin. For
6 clarity, conventional components such as upper valve
7 sleeve 80, lock segments 82, extension spring 84 and
8 equalizing mandrel 16 are numbered. All other
9 downhole components of the tool are conventional
10 except for pressure pathways as noted in each of the
11 figures. Pressure pathways are numbered in numerous
12 places on the figures to provide an understanding to
13 one of ordinary skill in the art as to the precise
14 location thereof.

15 Focusing on the sensor module 90 in this
16 embodiment of the invention, a sensor housing 92 has
17 an uphole profile 94 to act as a fishing neck which
18 functions as is known in the art. It will be
19 appreciated that in prior art bridge plugs the
20 fishing neck would be threaded directly to the
21 equalizing mandrel 16. In the invention however,
22 the equalizing mandrel 16 is threadedly connected to
23 a porting sub 95 threadedly connected to sensor
24 housing 92 at thread 96 and inner mandrel 98 at
25 thread 100. The connections to porting sub 95, as
26 stated, are sealed with o-rings 102.

27 A chamber 104 is created between inner mandrel
28 98 and sensor housing 92 which is sealed at the
29 uphole end by o-ring 106 against an i.d. of sensor
30 housing 92. Within chamber 104, electronic
31 equipment similar to the first discussed embodiment
32 is disposed. At least one electronic control

1 module(s) 108 is connected to pressure transducers
2 110 and 112. Pressure transducer 110 is connected
3 to pressure pathway 114 which leads to annulus
4 pressure downhole of the element 26. Plug 118 is
5 required incident to the manufacturing process to
6 prevent annulus pressure above the element 26 from
7 being registered. Conversely, pressure transducer
8 112 measures pressure in the annulus uphole of
9 element 26 through pressure pathway 120 which has
10 access to annulus pressure through port 122.

11 In this embodiment, power is provided to the
12 electronic components enumerated above via an
13 inductive coupler coil 124. Power will thus be
14 initiated at the surface or another remote power
15 source. Since batteries are not the limiting factor
16 on the life of this tool regarding testing of the
17 parameters readable by the electronics therein,
18 readings may be performed at any time, even many
19 years after installation of the tool simply by
20 providing power via a complementary coil (not
21 shown). The sensors so powered can then communicate
22 with a remote location or store data for later
23 retrieval through the inductive coupler which in
24 such an embodiment is employed as a communication
25 link to a remote location. In one embodiment, the
26 inductive coupler will not supply power at all but
27 rather will act solely as a communications pathway
28 and will function to extract data from the bridge
29 plug whether the data is stored or is being actively
30 recorded.

31 In yet another embodiment of the invention,
32 transmission of data is forsaken entirely. More

1 specifically, a battery pack is utilized to power
2 the tool and data is stored on the control module.
3 This activity would continue as long as the battery
4 pack supplies energy. Further the data storage
5 could be continuous or could be at time intervals.
6 Subsequently, when the bridge plug is pulled out of
7 the well, the stored data on the control module
8 could be downloaded for review and/or analysis. It
9 will be appreciated that other sensors for
10 parameters such as gamma radiation, temperature flow
11 and other element or formation parameter may be
12 added to any embodiment hereof.

13 While preferred embodiments have been shown and
14 described, various modifications and substitutions
15 may be made thereto without departing from the
16 spirit and scope of the invention. Accordingly, it
17 is to be understood that the present invention has
18 been described by way of illustrations and not
19 limitation.

1 **CLAIMS**

2

3 CLAIM 1. A downhole parameter sensing retrievable
4 bridge plug comprising:

5 an inflatable element;

6 a sensor module connected to said inflatable
7 element; and

8 at least one pressure transducer calibrated to
9 sense one of element pressure, annulus pressure
10 uphole of the element, annulus pressure downhole of
11 the element.

12

13 CLAIM 2. A downhole parameter as claimed in Claim 1
14 wherein said at least one pressure transducer is a
15 plurality of pressure transducers, each calibrated
16 to sense one of element pressure, annulus pressure
17 uphole of the element, annulus pressure downhole of
18 the element.

19

20 CLAIM 3. A downhole parameter as claimed in Claim 1
21 wherein said at least one pressure transducer is
22 connected to a pressure pathway provided in said
23 retrievable bridge plug terminating at an access
24 point to the target pressure.

25

26 CLAIM 4. A downhole parameter as claimed in Claim 1
27 wherein said at least one pressure transducer is in
28 pressure reading communication with direct element
29 pressure in said element.

30

31 CLAIM 5. A downhole parameter as claimed in Claim 1
32 wherein said bridge plug further comprises a

1 controller module operably connected to said sensor
2 module.

3

4 CLAIM 6. A downhole parameter as claimed in Claim 5
5 wherein said control module stores data received
6 from said at least one pressure transducer.

7

8 CLAIM 7. A downhole parameter as claimed in Claim 1
9 wherein said sensor module further includes a
10 transmitter operably connected to said at least one
11 pressure transducer, said transmitter having
12 transmission capability.

13

14 CLAIM 8. A downhole parameter as claimed in Claim 7
15 wherein said transmitter transmits acoustically.

16

17 CLAIM 9. A downhole parameter as claimed in Claim 8
18 wherein said transmitter transmits by radio
19 transmission.

20

21 CLAIM 10. A downhole parameter as claimed in claim 9
22 wherein said transmitter transmits by
23 electromagnetic transmission.

24

25 CLAIM 11. A downhole parameter as claimed in Claim 5
26 wherein said control module continuously releases
27 said stored data to a transmitter connected thereto.

28

29 CLAIM 12. A downhole parameter as claimed in Claim 5
30 wherein said control module upon command releases
31 said stored data to a transmitter connected thereto.

32

1 CLAIM 13. A downhole parameter as claimed in Claim 5
2 wherein said control module at intervals of time
3 releases said stored data to a transmitter connected
4 thereto.

5

6 CLAIM 14. A downhole parameter sensing bridge plug
7 comprising:

8 an inflatable element; and

9 a sensor sensing at least one parameter of the
10 element, and a transmitter capable of transmitting
11 information from said sensor to a remote location.

12

13 CLAIM 15. A downhole parameter sensing bridge as
14 claimed in claim 14 wherein said plug further
15 comprises additional sensors for at least one of the
16 elements and the formation.

17

18 CLAIM 16. A downhole parameter sensing bridge as
19 claimed in claim 15 wherein said sensors sense at
20 least one of temperature, flow rate, pressure, gamma
21 radiation, radio waves, electromagnetic wave or a
22 combination with at least one of the foregoing.

23

24 CLAIM 17. A downhole parameter sensing bridge as
25 claimed in claim 14 wherein said transmitter
26 transmits one of acoustically, by radio wave, by
27 electromagnetic wave, and by vibration.



INVESTOR IN PEOPLE

Application No: GB 0109632.0
Claims searched: 1-17

Examiner: Eleanor Wade
Date of search: 31 August 2001

Patents Act 1977

Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): E1F FKA, FKF

Int Cl (Ed.7): E21B

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2349657 Baker Hughes (whole document)	-
X	US 5868201 Baker Hughes (col 24 line 3 to col 25 line 34 and fig 10)	1,5-10, 14-17
A	US 5417122 Casey et al. (whole document)	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.